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TOXICANT ENTRAINMENT TEST -  
CLOTHING OUTFIT, ROCKET  
FUEL HANDLERS A/P 22P-1

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## I. Introduction

The Clothing Outfit, Rocket Fuel Handlers A/P 22P-1 is used by personnel facing possible exposure to Titan II propellants in either the liquid or vapor form. During normal operations, personnel may accidentally tear the suit on exposed hardware. The general objective of this test was to determine the danger involved to personnel wearing torn protective clothing while subjected to vaporous propellants. The test was conducted using only  $\text{NO}_2 - \text{N}_2\text{O}_4$  vapors. The test was conducted in a chamber built at the Martin Company's Cold Flow Laboratory. The original plan was to have nine runs each with a tear at a different location and control the chamber  $\text{N}_2\text{O}_4$  concentration at 10%  $\text{N}_2\text{O}_4$  for 16 minutes and then increase the concentration to 50% for 16 minutes. Because of the difficulty to obtain a concentration and holding it with the equipment used, this plan was changed. The  $\text{N}_2\text{O}_4$  tank was agitated and the vapors were purged into the toxicant entrainment test chamber continually during the test giving a continual increase in concentration in the test chamber. A circulating fan was located in the chamber to keep the vapors mixed. By following the same procedure during each run, it was attempted to have the same concentration in the test chamber at the corresponding time during each run. The test chamber was 8 x 8 x 8 feet.

## II. Test Procedure

The clothing outfit was placed on a standing manikin and placed in the center of the test chamber. A tear four inches on a side was put in the required position on the suit. The various tear locations corresponding to the run number are shown in Figure 1. Two tubes were taped inside the suit. One to the mouth of the manikin and the other adjacent to the tear approximately two inches above it. The tubes emerged from the suit through the tear and terminated at two American Systems Incorporated (ASI) sensors located outside the test chamber. These sensors give a continuous reading in parts per million of the concentration inside the suit by continually pumping a sample through the sensor. The ASI sensors were calibrated and turned on. The Environmental Control Unit (ECU) in the suit was turned on, and this time was recorded as the test start time on the data sheet. The zipper was closed on the suit, and the chamber door was closed. The chamber circulating fan was turned on. The ASI sensor reading was taken at time 0. The  $\text{NO}_2 - \text{N}_2\text{O}_4$  vapor was added to the chamber with the data sheet showing time from initiation of flow of vapors into the chamber.

Two chamber-sampling ports located on one wall at three feet and five feet above floor level. Chamber samples were taken 3 minutes after the start of  $\text{NO}_2 - \text{N}_2\text{O}_4$  vapor flow and then at about ten minute intervals until the end of the run. Occasionally samples were taken

## II. Test Procedure (Continued)

at both the three and five foot levels to check the homogeneity of the atmosphere inside the chamber. These samples were analyzed during and after the test run using the pH method to determine the concentration in parts per million.

Concentrations inside the suit were monitored continuously and periodic readings were made on the data sheet. Each test run was stopped either when the ECU was about to run out of air or the concentration at one of the sensors inside the suit reached 250 ppm, the upper limit of these sensors. When one sensor reached 250 and the other didn't, the sensor tube was changed to insure that the lower sensor would agree with the reading when connected to the same location. After each run, the chamber was purged and the suit decontaminated and patched to prepare for the next run.

## III. Test Results

Nine runs were conducted during the test. The test data sheets for each run are included at the end of this report. Figure 1 shows the tear locations corresponding to test number. Figure 2 shows the concentration inside the suit at the mouth of the manikin versus time.

The data shows that after the first test run even though the suit was decontaminated between runs, there was a residual concentration inside the suit. This concentration was listed as the concentration at time 0.

Run number 2 was the only run where switching the sensor lines when one sensor reached 250 ppm did not give the same results on both sensors. The early readings on run 2 may have been high.

The test data shown in Figure 2 shows that the concentration inside the suit builds up faster and higher the closer a tear occurs to the recirculation inlet in the ECU.

In general, the concentration at the head sensor was higher than that two inches above the tear.

## IV. Conclusions

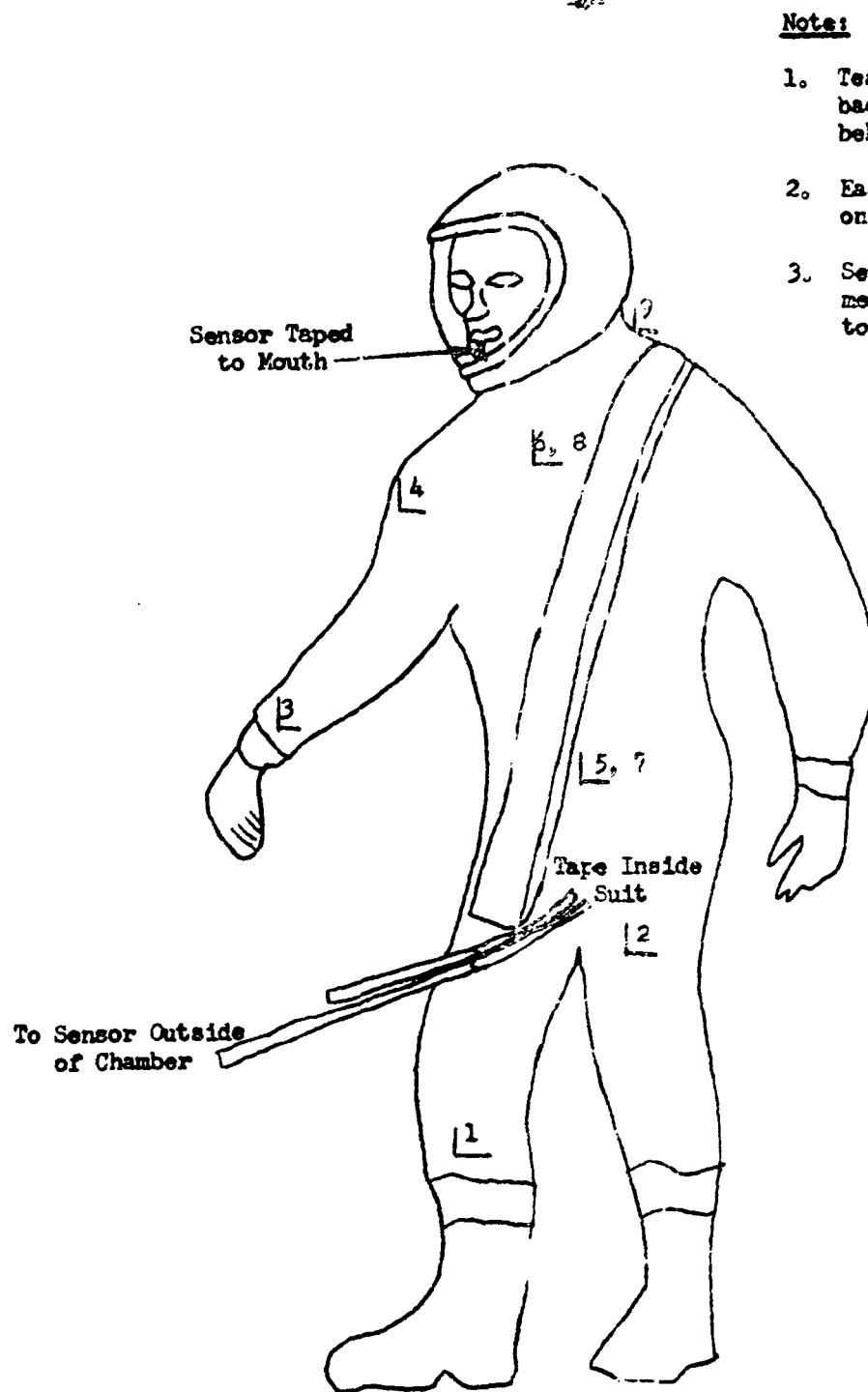
Under normal operation, the suit is pressurized to 0.5 inches of water pressure from the ECU's air flow in conjunction with the suit pressure relief valves. When the suit is torn, it deflates and the air flow escapes through the hole. By placing a source of smoke just outside the hole, it will be blown away with no smoke entering that

#### IV. Conclusions (Continued)

can be seen. This test shows that  $\text{NO}_2 - \text{N}_2\text{O}_4$  vapors will enter the suit against this air flow out of the hole. In fact, it will enter the suit at such a high rate that any suit wearer who notices his suit has deflated because of a tear should go to a safe area and get out of that suit immediately. The suit still gives some protection to the wearer while leaving the area but the concentration inside the suit goes above safe limits almost immediately.

The test shows (Figure 2) that the closer a tear occurs to the recirculation inlet of the ECU, the faster the concentration builds up in the helmet which receives most of the air flow from the ECU.

The concentration at the tear was lower than at the head because of the high velocity of air going out of the tear from all directions around the tear. In general, the concentration at the tear was the same for all tear locations with respect to time.



Notes:

1. Tear 7 & 8 are on back of suit directly behind 5 & 6.
2. Each tear is 4 in. on a side.
3. Sensing tube in helmet will be taped to mouth on manikin.

FIGURE I  
Tear Locations





DATA SHEET

Test Run No. 1 & 2

Tear Location Right Leg & Left Thigh

Date of Test 12-27-63 & 12-30-63

Test Start Time 9:19 & 9:32

Test Stop Time 10:23 & 10:25

Test Run No. 1

TIME	N <sub>2</sub> O <sub>4</sub> CONCENTRATION - PPM	HEAD ASI NO. 009 TEAR ASI NO. 007	
Min.	Test Cell	Head PPM	Tear Location PPM
3	3 Ft. 25,000		
5		5.0	8.5
6	3 Ft. 70,000		
7		10.0	14.0
9		13.0	19.5
13		19.0	28.0
15	3 Ft. 240,000		
17		25.0	34.0
21	3 Ft. 255,000	26.5	40.0
25		29.0	53.0
37	3 Ft. 520,000 - 5 Ft. 440,000	31.0	55.0
Test Run No. 2			HEAD ASI NO. 007 TEAR ASI NO. 009
0		4.5	1.0
3	3 Ft. 15,500	98.0	6.5
4		160.0	11.5
5		200.0	17.5
6		230.0	25.0
7		250.0	
NOTE: CHANGED ASI SENSORS AT THIS POINT			
9		180.0	
11		175.0	84.0
14	3 Ft. 150,000 - 5 Ft. 300,000	120.0	100.0
18		125.0	110.0
21		145.0	120.0
24	3 Ft. 350,000	170.0	140.0
29		170.0	150.0
31		190.0	160.0
35	3 Ft. 490,000	195.0	175.0
38		200.0	190.0
40	3 Ft. 700,000 - 5 Ft. 620,000	200.0	190.0

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DATA SHEET

Test Run No. 3 & 4

Tear Location Right Wrist & Right Shoulder

Date of Test 1-2-64 & 1-3-64

Test Start Time 11:20 & 9:30

Test Stop Time 12:17 & 10:04

Test Run No. 3

TIME	N <sub>2</sub> O <sub>4</sub> CONCENTRATION - PPM	HEAD ASI NO. 007 TEAR ASI NO. 018	
Min.	Test Cell	HEAD PPM	Tear Location PPM
0	3 Ft. 20,000	18.0	10.0
3		27.5	17.0
5		46.0	30.0
8		54.0	34.0
10	3 Ft. 105,000 - 5 Ft. 105,000		
12		40.0	29.5
15		45.0	37.0
18		60.0	42.0
20	3 Ft. 250,000	65.0	47.0
24		80.0	57.0
28		90.0	71.0
30		100.0	77.0
36	3 Ft. 475,000	115.0	93.0
42		130.0	110.0
45	3 Ft. 520,000 - 5 Ft. 485,000	155.0	123.0
<u>Test Run No. 4</u>			HEAD ASI NO. 020 TEAR ASI NO. 007
0	3 Ft. 17,000	2.5	3.5
2		4.0	3.9
3		5.5	5.0
5		9.5	8.5
8	3 Ft. 65,000 - 5 Ft. 63,000	17.0	14.5
10		22.0	20.0
12		29.5	28.0
15		43.0	45.0
18	3 Ft. 142,000	49.0	68.0
20		69.0	88.0
24		132.0	155.0
28		250.0	220.0
29	3 Ft. 175,000	Off	250.0

DATA SHEET

Test Run No. 5 & 6

Tear Location Left Hip & Front Chest

Date of Test 1-6-64 & 1-7-64

Test Start Time 8:56 & 9:15

Test Stop Time 9:01 & 9:36

Test Run No. 5

TIME	N <sub>2</sub> O <sub>4</sub> CONCENTRATION - PPM	HEAD ASI NO. 020 TEAR ASI NO. 007	
Min.	Test Cell	Head PPM	Tear Location PPM
0	3 Ft. 75,000	2.6	2.0
3		21.0	2.0
5		48.0	4.0
8	3 Ft. 45,000 - 5 Ft. 43,000	94.0	9.0
10		136.0	14.0
12		210.0	22.0
14	3 Ft. 105,000	250.0	31.0
16			
Test Run No. 6			HEAD ASI NO. 020 HEAD ASI NO. 007
0	3 Ft. 4,400	3.4	2.0
3		8.0	2.0
5		22.0	3.7
7	3 Ft. 7,500	50.0	7.0
10	3 Ft. 44,000	105.0	12.0
12		150.0	15.0
16		250.0 +	24.0

DATA SHEET

Test Run No. 7 & 8

Tear Location Back-Below & Back, Middle  
Back Pack of Back Pack

Date of Test 1-19-64 & 1-9-64

Test Start Time 9:25 & 1:03

Test Stop Time 10:08 & 1:20

Test Run No. 7

TIME	N <sub>2</sub> O <sub>4</sub> CONCENTRATION - PPM	HEAD ASI NO. 020 TEAR ASI NO. 007	
Min.	Test Cell	Head PPM	Tear Location PPM
0		0.5	0.5
3	3 Ft. 6,800	6.5	1.4
5		11.0	2.25
10	3 Ft. 20,000 - 5 Ft. 20,000	23.0	6.0
12		31.0	7.5
15		47.0	13.0
17		72.0	21.0
20	3 Ft. 73,000	92.0	29.0
22		105.0	35.0
25		135.0	46.0
27		170.0	48.0
30	3 Ft. 150,000	200.0	61.0
32		235.0	85.0
33		250.0	250.0
35	3 Ft. 186,000		
Test Run No. 8		HEAD ASI NO. 020 HEAD ASI NO. 007	
0		2.0	2.0
1		17.0	9.0
3	3 Ft. 33,500	37.0	15.5
5		50.0	23.0
7		86.0	32.0
10	3 Ft. 85,000 - 5 Ft. 84,500	135.0	45.0
12		180.0	60.0
15		225.0	78.0
16½	3 Ft. 131,000	250.0	92.0

DATA SHEET

Test Run No. 9

Tear Location Back of Neck

Date of Test 1-10-64 Test Start Time 9:09 Test Stop Time 9:29

Test Run No. 9

TIME	N <sub>2</sub> O <sub>4</sub> CONCENTRATION - PPM	HEAD ASI NO. 007 TEAR ASI NO. 020	
Min.	Test Cell	Head PPM	Tear Location PPM
0	3 Ft. 20,000	2.5	2.0
3		29.0	13.0
5		75.0	42.0
7		105.0	50.0
10	3 Ft. 105,000 - 5 Ft. 50,000	250.0 +	250.0 +